

NxtPhase Optical Sensors Measurement Stability Over Time and Temperature

Introduction

Instrument transformers used in power systems, especially those used for metering applications, must maintain stability of measurement over time, and through different environmental conditions. The changing of scale factor due to temperature, or scale factor drift over time, contributes to less than intended metering accuracy, impacting revenues; and may require continual calibration of revenue meters. Some conventional instrument transformers, especially CTVTs, and some polarimetric-based optical sensor systems have experienced a drift in accuracy as they age, and due to temperature conditions.

The interferometric-based optical sensor systems from NxtPhase are field-proven to have a stable scale factor over time and temperature. For example, 19 months of data from an installation of an NXVCT at a substation in Arizona shows that stability is excellent, with no significant correlation between daily temperature, seasonal temperature, time, and accumulated energy.

NXVCT at the APS Deer Valley 230 kV Substation

This Application Note discusses data collected from an NXVCT Optical Voltage and Current Sensor at Deer Valley Substation, operated by Arizona Public Service, in north Phoenix, Arizona. The substation steps power down from a 230kV transmission line from the Salt River Project to 69kV for distribution to Phoenix and Glendale, Arizona. On average, the power flow through the transformer is 200A, or about 2GWhr of energy daily.

The NXVCT is installed to measure power flow through the 230kV:69kV transformer. The NXVCT is installed in parallel with conventional VTs, and in series with conventional CTs, to provide a performance reference. Both types of sensors are connected to energy meters, using a Class 20 meter for the conventional instrument transformers, and a Class 2 meter for the NXVCT.

The meters began recording data on June 15th, 2002, and this Application Note discusses data recorded through December 31st, 2003, a total of 19 months, and 4 seasonal extremes (summer/winter, summer/winter).

Metrology

The accumulated uncertainty of the energy measurement will be $\pm 0.30\%$ for the optical system and $\pm 0.44\%$ for the conventional system¹. The accumulated energy difference comparison between the systems would lead to a $\pm 0.74\%$ uncertainty.²

Performance Over Time and Temperature

Figure 3 shows the monthly-accumulated energy (MWh) and the average monthly high and low temperatures at the Deer Valley substation between June 15, 2002 and December 31, 2003. Measurements from the conventional instrument transformers are used as the reference data. An optical sensor system should maintain the $\pm 0.74\%$ uncertainty against this measurement over the entire range of the data.

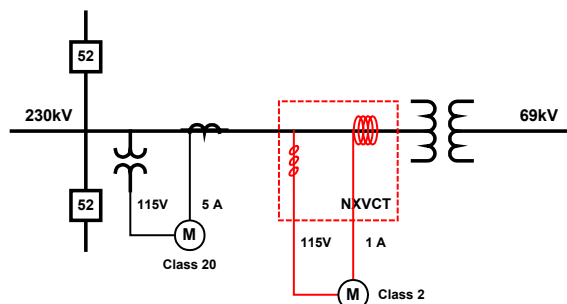


Figure 1. APS Deer Valley Substation Oneline.

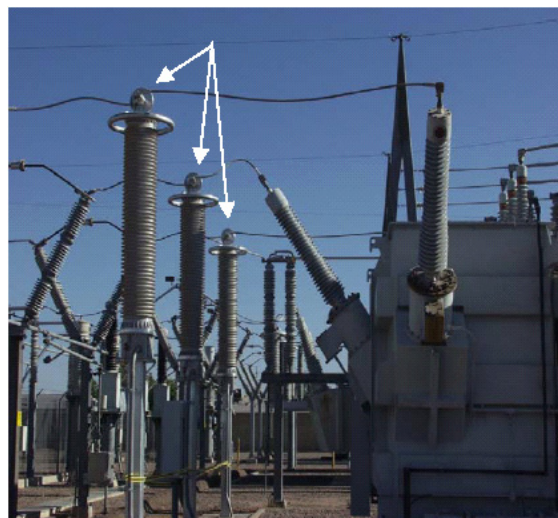


Figure 2. NXVCTs at the APS Deer Valley Substation.

¹ Accumulated uncertainty calculated from:

Meter uncertainty: The Transdata energy meters have a stated uncertainty and the control room is air-conditioned with approximately $\pm 2^\circ\text{C}$ variation over the year. Meter temperature sensitivity should not contribute significantly to any variations seen in this report.

Conventional VT uncertainty: the GE Type EW-900, 0.3WXYZZ devices are assumed to have $\pm 0.3\%$ uncertainty and no temperature dependence.

NXVCT uncertainty: NXVCTs have an uncertainty of $\pm 0.2\%$ for both voltage and current, and hold this uncertainty over a wide temperature range, -40°C to 50°C .

² Refer to calculations in Appendix A.

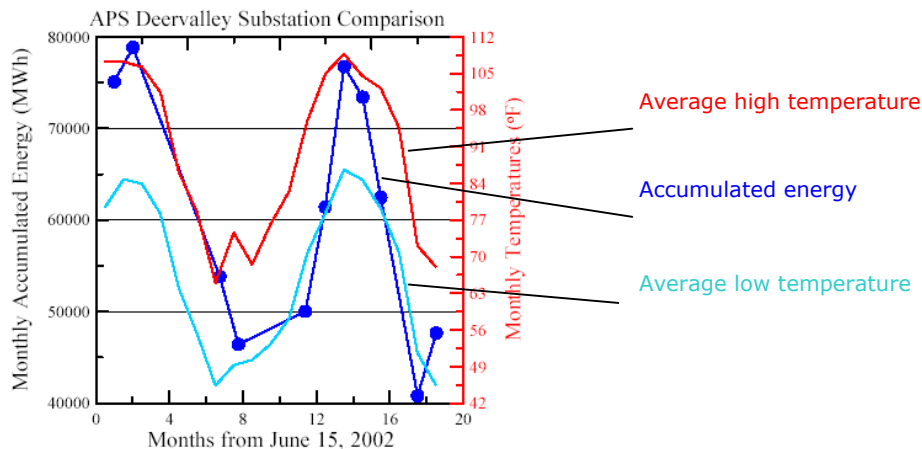


Figure 3. Monthly accumulated power and average monthly temperatures³ at the Deer Valley substation.

Figure 4 shows the total accumulated energy difference (%) between the conventional and NxtPhase devices, as well as the average monthly high and low temperatures over the same period. The mean energy difference is about 0.08% over the 18.5 month time period.

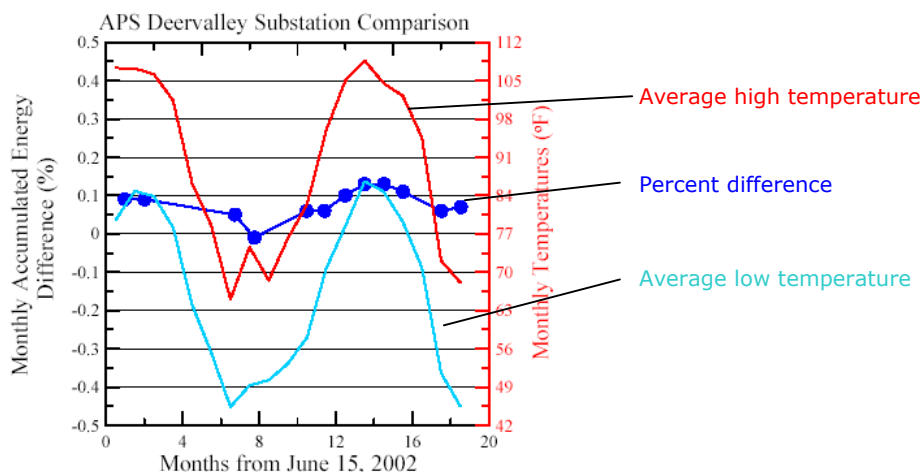


Figure 4. Percent difference in monthly accumulated energy between NxtPhase sensors and conventional transducers, including average monthly temperatures at the Deer Valley substation.

The data shows the NXVCT performs extremely well over time, and varying temperatures, versus the conventional instrument transformers. The seasonal variation in energy difference is only $\pm 0.07\%$, well within the expected uncertainty of the differences in energy measurements of $\pm 0.74\%$.

Conclusions

The seasonal data presented in this report cover a four-season period from June 15, 2002 to December 31, 2003, for an NXVCT Optical Voltage and Current Sensor. Measurements from the optical units compare well with the conventional units used to meter the energy flow. In addition, seasonal variation in measurement is extremely small.

As illustrated by this four-season (summer/winter/summer/winter) comparison, the stability of the NxtPhase optical sensors with interferometric design is excellent, with no significant correlation between daily temperature, seasonal temperature, time and accumulated energy

³ Temperatures taken by U.S. National Weather Service (Phoenix office) at Sky Harbor Airport in downtown Phoenix, Arizona. Deer Valley Substation is about 36 km (22.5 miles) north of the airport and may have a few °F variation from airport data.

Appendix A – Total uncertainty calculations

The total uncertainty (U) of the comparison measurement was estimated as follows:

$$\text{Optical energy } U = \sqrt{(OCT^2 + OVT^2 + \text{Powermeter}^2)} = \sqrt{(0.20^2 + 0.20^2 + 0.10^2)} = 0.30\%$$

$$\text{Conventional energy } U = \sqrt{(CT^2 + VT^2 + \text{Powermeter}^2)} = \sqrt{(0.30^2 + 0.30^2 + 0.10^2)} = 0.44\%$$

$$\text{Total } U = \text{Optical energy } U + \text{Conventional energy } U = 0.74\%.$$

In the above calculations, it is assumed that voltage measurements, current measurements, and energy meters' calculations are independent of one another (uncorrelated), but errors in similar devices on different phases, e.g., all three conventional VTs, are correlated (because of similar burden on all phases, same ambient temperature, etc.)